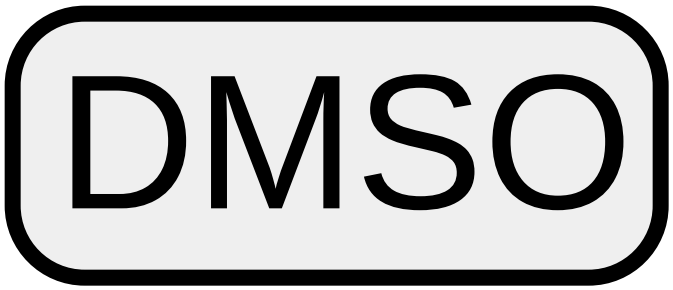

Department of Defense

High Level Architecture

OMT Use Cases

Version 0.3

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Foreword

The contents of this document are based upon the HLA Federation Object Model (FOM) development experiences of the HLA protofederations. Since the format of the HLA Object Model Template (OMT) was continually evolving during this prototyping period, the format of the OMT table examples provided in this document may or may not be consistent with the current version of the HLA OMT. Nevertheless, it is believed that the description of the process utilized in each individual application area, culminating in the population of the OMT tables, will be instructive and useful to HLA federation developers .

1.0 Purpose

The DoD Modeling and Simulation Master Plan [DOD95] calls for the establishment of a DoD-wide High Level Architecture (HLA) for modeling and simulation, applicable to a wide range of functional applications. The purpose of this architecture is to facilitate interoperability among simulations and promote reuse of simulations and their components.

A named set of simulations interacting via the services of the HLA Runtime Infrastructure (RTI) and in accordance with a common object model and a common HLA rule set is known as a HLA *federation*. The HLA Federation Development and Execution Process (FEDEP) Model defines a high-level process by which HLA federations can be developed and executed to meet the needs of a federation sponsor. A complete description of the HLA FEDEP Model can be found in the HLA Technical Library.

One of the most important activities in the early-mid phases of the HLA FEDEP Model is the development of the HLA Federation Object Model (FOM). The purpose of this document is to provide a series of case studies, or use cases, to illustrate how the recommended practices and guidelines for FOM development discussed in the HLA FEDEP Model may be instantiated in different ways depending on the specific community of use. The content for each of these use cases is based upon the experiences of the HLA protofederations. In the future, as new HLA users initiate the process of developing a federation, it is believed that the specific examples and breadth of experience documented in these use cases will provide a strong foundation for FOM development across many different application areas.

A secondary purpose to this document is to provide actual examples of how the HLA Object Model Template (OMT) tables are populated during FOM development. HLA federation developers may exploit these case studies to increase their understanding of how the OMT formats support the specification of HLA FOMs.

2.0 Engineering Protofederation Use Case

The intent of this FOM Development Process Model use case is to notionally show how the Engineering Protofederation of the HLA program would apply the principles of the Federation Development and Execution Process (FEDEP) model toward the development of a notional FOM. This use case focuses on a hypothetical version of the Engineering Protofederation's Problem Domain and the notional activity that would have been performed to develop components of the Engineering Protofederation's FOM. For reasons of security classification and documentation brevity, the Engineering Protofederation use case has been stylized. Although FOM development is the primary emphasis in this use case, the interdependency of the Engineering Protofederation's Federation Execution Management and Execution Environment constraints and the FOM development process necessitated the inclusion of a discussion on the development of select Federation Required Execution Details.

The Engineering Protofederation was established for the purpose of assessing the implications of the HLA on the development and execution of typical distributed Systems Engineering and Test & Evaluation systems assessments. Though there was no explicit Federation Execution Sponsor for the Engineering Protofederation (i.e., no sponsor with a military systems evaluation objective in mind), the Engineering Protofederation members have the organizational sponsorship of the Defense Test & Evaluation community and the Defense Systems Design and Evaluation community. The multiplicity of the implied DoD organizational sponsorship of this use case resulted in the selection of a set of distinct Engineering Protofederation Scenarios, Federation Executions and Execution Objectives. The use case shows how the notion of Federation Execution sponsorship is used to drive the FEDEP and logically lead to the development of the notional Engineering Protofederation FOM.

Only a select subset of the overall Engineering Protofederation's Execution development activity will be covered in the use case. A "notional" Federation Sponsor's problem domain was established to illustrate the manner in which a Federation Execution Sponsor's implicit and explicit requirements could be systematically refined through successive stages of the Federation Development and Execution Process. The notional Engineering Protofederation Sponsor's problem domain that was selected for this use case is directly tied to the Electronic Warfare (EW)

Developmental Test and Evaluation (D,T&E) problem domain. As such, the use case in this section presents a Federation Development and Execution processing thread as if the Engineering Protofederation had used the HLA to develop and execute a Developmental Test and Evaluation (D,T&E) of a new EW subsystem as a Defensive Avionics retrofit for a generic USN Deep-Strike attack aircraft.

The application chosen for this use case represents a somewhat rigorous instantiation of the Federation Development and Execution Process model. It is expected that other communities of interest may develop alternative instantiations of this process within the generalized framework and guidelines presented in the FEDEP Model description. However, it is hoped that this particular example of OMT usage within the Federation Development and Execution process will prove instructive and useful across a wide variety of potential applications, and contribute sufficient insight into the FOM development process to provide a frame-of-reference for new federation developers.

Finally, the flow of the discussion that follows addresses three separate but interleaved views that are required for an orderly Federation Development and Execution Process: (1) an Operational Scenario View (shared by Execution Sponsors and Conceptual Analysts), (2) a Federation Execuiton Composition View (shared by Federation Designers and Federation Developers), and (3) a Federation Execution View (shared by Federation Execution Managers/Directors and Federation Execution Instrumentation/Data Collection Controllers). It is important that these three views are kept in mind so as to not confuse the processing purposes of each of the Federation Development and Execution processing steps. For example, the development of Operational Scenario Objects (part of the Scenario Developer's and Conceptual Analyst's view) is distinct from the development of Federation Execution Objects. In fact, the former feeds the later.

2.1 Objectives Development

The purpose of Objectives development process is to provide the Federation Execution Sponsor (a.k.a., Sponsor) a systematic process for: (a) the identification of the Sponsor's problem domain (so as to pinpoint the domain for the Conceptual Analysis process), (b) the elaboration of specific Operational Context requirements associated with the Sponsor's problem domain, and (c) the

development of problem-domain-specific Reference Requirements for Federation Execution Management. There are three primary activities that comprise the Federation Sponsor's Objectives development process:

- Problem Domain Identification,
- Operational Context Elaboration, and
- Federation Execution Management Reference Requirements Specification

2.1.1 Problem Domain Identification

This processing activity must enable the Federation Sponsor to clearly identify: (1) the Federation Execution Sponsor's Problem Class, (2) the critical SUE Operational Objects (e.g., those objects associated with SUE (Systems Under Evaluation) that are expected to exhibit the most sensitivity between the SUE and the Operational Interaction Context Objects, (3) the SUE's Operational Context Objects, and (4) the critical SUE Measures of Merit for the Federation Execution. For clarification purposes, the term System Under Evaluation (SUE) is used to refer to any systems that the Sponsor is going to evaluate using the Federation Execution. A SUE may be representative of humans being trained, operational tactics, logistical policies, specific hardware being tested, notional design concepts, aggregate groupings of warfighters...etc. Depending on the problem domain, the sponsor will have significantly different levels of specificity for SUE Operational Objects and the Operational Context Objects that interact with the SUE. The more specific that the Sponsor can be with the problem domain description, the more focused the Conceptual Analysis process.

To systematically identify the problem domain, the Sponsor will derive operational objectives and operational scenario contexts derived from the formal Federation-Domain-Specific Operational Requirements Documents (ORD) and Mission Element Needs Statements (MENS). It is expected that these formal ORDs and MENs documents will baseline requirements specifications from which the specific Federation Execution Sponsor's Problem Domain specifications can be systematically derived. Implied in the FEDEP model is an iterative process that the Federation Execution sponsor uses between the Problem Domain Identification process and the Conceptual Analysis and Scenario Development processes. If the Sponsor can only specify his problem domain to a limited degree, then the Conceptual Analysis of the FEDEP will support the refinement of the Sponsor's problem domain specification in terms that have

operational meaning to the Sponsor and Federation Design meaning for the Federation Execution Developer at the same time.

The notional Engineering Protofederation Problem Domain for this use case is selected to be the domain of Electronic Warfare (EW) Developmental Test and Evaluation (D,T&E). The notional Federation Execution Sponsor's Objective is to: "evaluate the level of enhanced capability that the notional USN Fighter/Attack Aircraft could achieve when retrofitted with a new EW-CM Subsystem (termed the "EW-Associate CM Subsystem" for the Engineering Protofederation HLA prototyping activity). A succinct description of the notional Sponsor's problem domain objective statement is as follows:

EW-Associate ECM Subsystem D,T&E Notional Sponsor's Objective Statement

> Conduct: (1) an Electronic Warfare Systems Developmental Test and Evaluation to assess: (2) the Operational Performance Improvement associated with: (3) the "EW-Associate" CM Subsystem as a retrofit to: (4) the notional USN Fighter/ Attack Defensive Avionics System as a function of: (5) an innovative EW-Associate's Defensive Response Strategy Display operating within: (6) the Deep Interdiction Strike Mission Context.

The output of the Problem Domain Identification activity corresponds to the specific entries that the Execution Sponsor would develop for each of the "underlined information categories" within the notional Execution Sponsor's Objectives Statement. Each of the underlined Execution Sponsor's entries establishes an index reference to a specific class of Federation Development and Execution processing that would be performed in subsequent Federation Development and Execution processes. For example, underlined items #1, #3, #4, and #5 would point to required Conceptual Analysis activity, underlined items #3, #4, #5, and #6 would point to required Scenario Development activity, and underlined items #1 and #2 would point to required Reference Requirements for Federation Execution Management. Section 2.2 illustrates how the underlined statements lead to focused Scenario Development processing activities. Section 2.3 illustrates how the underlined statements lead to focused Conceptual Analysis processing activities.

2.1.2 Operational Context Elaboration

This activity allows the Federation Sponsor to elaborate the Operational Context that has been declared during the problem domain identification activity. Included in this elaboration of Operational Context would be any of the Sponsor's problem-domain-specific requirements for: (a)

geographic conditions (and Objects), (b) diurnal conditions, (c) immersion environment conditions, (d) friendly/neutral support objects, (e) "targeting" objects, (f) threat objects,...etc. For clarification, Operational Context must be relative to the Sponsor's SUE. There is diminishing (to potentially negative) value in an over-specified Operational Context that may include context objects that have only a minor interaction with the SUE. By the same token, there may be erroneous evaluation results that arise due to an under-specified Operational Context. If the Federation Sponsor is only able or required to provide a partial elaboration of the Operational Context, then any required or desired refinements for the Operational Context will take place (and be approved) during iterations between the Scenario Development and Conceptual Analysis processes.

For the use case, the Engineering Protofederation's notional Operational Context elaboration was developed in order to enable the EW-Associate CM Subsystem D,T&E Sponsor to effectively test and evaluate the EW-Associate CM Subsystem performance (i.e., Operational Effectiveness). The EW-Associate CM Subsystem would most likely be designed to enhance the notional USN Fighter/Attack aircraft capacity to respond to specific classes of Threat Systems. It is necessary, therefore, that the Sponsor elaborate those specific threat objects and interactions that drive the SUE object interfaces and must be the focus of the Conceptual Analysts and Scenario Developers. For the use case being addressed, the Operational Context elaboration for the EW-Associate CM Subsystem D,T&E Sponsor's problem can be represented by the following elaboration statement:

The Deep Interdiction Strike Mission Context Elaboration Statement

> The Deep Interdiction Strike Mission Context is to be representative of: (1) a Sponsor-Approved geographic location. The test and evaluation mission context is to be representative of: (2) mid-day lighting conditions within: (3) a clear, summer atmospheric condition. The notional USN Fighter/Attack aircraft Deep Interdiction Strike package will be supported by: (4) a notional "Blue" USN AWACS (Surveillance/C3I Aircraft System). The targeting objective is the: (5) "XX" Airfield being defended by: (6) the "YY" Threat Systems Classes at the target area, and by: (7) the "ZZ" Threat System Classes along the notional USN Fighter/Attack aircraft Ingress and Egress navigation corridors. All Threat Systems will be under the support of: (8) a RED AWACS Surveillance System and the "ABC" SAM Intercept and Ground-based Early Warning C3I Networks.

As was the case for the Problem Domain Identification activity, the output of the Operational Context Elaboration activity would be associated with the underlined statements. For this use case the Context Elaboration is purposefully general for reasons of security classification. A comprehensive Engineering Protofederation Context Elaboration would most likely be

classified if specific details were to be supplied. The underlined statements in the Context Elaboration Statement pinpoint specific Conceptual Analysis and Scenario Development processes as well as Object Repositories that would be used to further evolve the Engineering Protofederation's FOM development and Federation Development and Execution.

2.1.3 Federation Execution Management Reference Requirements Specification

This activity supports the Sponsor in defining any specific Reference Requirements that must be satisfied by the Federation Design and Federation Development and Execution processes. The Federation Execution Management Reference Requirements fall into 3 broad categories: (1) Sponsor's resource limitations (funds, schedule, Execution Participant manpower,...etc.), (2) Sponsor's Problem-Domain-Specific physical execution architecture requirements (simulation/ stimulation facilities, simulation/stimulation assets and/or Federation Execution topology requirements), and (3) Federation Execution management & control tolerances (object interaction latency limits, execution repeatability constraints, "realism thresholds",...etc.).

The Federation Execution Management Reference Requirements that are specified by the Federation Execution Sponsor may subsequently be relaxed based on assessments of the Federation Design and Federation Development and Execution "cost/benefits". Reference Requirements for cost, schedule, and security are also expected to place additional requirements on the Engineering Protofederation Sponsor's Federation Design and Development process. Though these requirements have significant implications for Federation Development, they have only marginal impact on the notional EW-Associate Sponsor's FOM development process and, therefore, are not mentioned further.

The output of this activity identifies specific Federation Execution Management Reference Requirements that may be required to support the Sponsor's Objectives. As an example, Table 2-1 illustrates how the EW D,T&E Sponsor's requirements could lead to specific "Simulation Ownership" requirements and associated Federation Execution Environment (a.k.a., "Federation Physical Processing Architecture) constraints.

2.2 Scenario Development

The purpose of this process is to develop a baseline Operational Scenario specification that: (a) enumerates and "instantiates" (i.e., "types and locates") the Federation Execution Sponsor's Operational Context with Scenario Objects and (b) classifies and characterizes the Scenario Object Interactions, Behaviors, and Associations that must be represented within the Federation Execution. The previous Operational Context Elaboration defined the classes of Scenario Objects that were of interest to the Execution Sponsor, this process provides specifications for locations, numbers, and types of Scenario Objects.

Table 2-1- Derived* Engineering Protofederation Execution Management Reference Requirements

Problem Domain Identification Item	**Derived Fed. Exec. Mgmt. Reference Requirement****
D,T&E; notional EW-Associate CM Subsystem Display for a USN Fighter/Attack Aircraft Configuration	The ACETEF (Aircraft Combat Effectiveness Test & Evaluation Facility) is required for performing D,T&E for installed USN Fighter/Attack Aircraft Avionics. ACETEF must "own" the USN Fighter/Attack Crew Systems, Threat Warning Sensors, and the EW-Associate Display in order to adequately represent the proper Stimulus/Response sensitivities of the highly-interacting SUE Subsystems and Components.
EW-Associate CM Avionics Subsystem Processor	The IDAL (Integrated Defensive Avionics Laboratory) is assumed to be currently used for designing the EW-Associate CM processor and for proprietary reasons, is the only facility that may take "ownership" of the EW-Associate Avionics processing software outputs.
Threat Systems "YY" and "ZZ"	The EW-Associate CM D,T&E Protofederation Execution requires high fidelity for specific Threat and Threat/ECM Systems interaction simulation. Therefore, Threat "YY1" must be owned by the AFEWES (Air Force Electronic Warfare Environment Simulator) facility, Threat YY2 must be owned by MSIC (Missile and Space Intelligence Center) facility, and Threat "ZZ" must be owned by ECSRL (Electronic Combat Simulation Research Laboratory) facility
RED AWACS Surveillance System and the "ABC" Early Warning and SAM Intercept Center and Associated Ground-based C3I Network	Because of the critical importance of the Threat's surveillance and C3I systems fidelity to the validity of the EW-Associate CM Operational Context and Operator Response interaction timing, the Threat's surveillance and C3I systems simulations must be "owned" by the REDCAP facility.

* Derived from the Sponsor's Problem Domain Identification process
** See Figure 2-7 ahead for the distribution of "Object Ownership" within the notional Federation

The Scenario Development process uses the outputs from the Sponsor's Operational Context Elaboration as well as the Scenario Object development activity of the Conceptual Analysis process to develop the operational scenario that the Sponsor wishes to simulate in the Federation Execution. Scenario Development consists of four activities:

- Scenario Object Enumeration and Spatial Placement,
- Scenario Object Interaction Allocation,
- Scenario Object Association Allocation, and
- Scenario Object Behavior State Allocation

The Federation Development and Execution Process model supports a systematic iteration between the Conceptual Analysis, the Scenario Development, and the Sponsor's Objectives development. The discussion that follows illustrates a single iteration between the Scenario Development process and the Conceptual Analysis process. Section 2.3 provides a discussion of the different iteration levels that the Conceptual Analysis process could take to mature both the Scenario and the requirements specification for the Federation Design process.

2.2.1 Scenario Object Enumeration and Spatial Placement

This activity develops a comprehensive Reference Operational Scenario together with the instances of and placements for the critical Operational Objects that are to be simulated. Initially, a preliminary Conceptual Analysis activity would have been performed as part of an iterative processing activity between the Scenario Development and the Conceptual Analysis processes (see Section 2.3). Depending on the type of Sponsor's problem being addressed, the Scenario Object Enumeration and Spatial Placement activity would access Reference Operational Scenario models and then perturb these models to represent any specific Interaction Context that was important to the Federation Execution Sponsor.

For the use case, the Engineering Protofederation used JCS-Approved operational scenario models as a starting point for developing the EW-Associate CM Subsystem D,T&E Scenario. The Scenario Development process perturbed these reference scenarios in order to develop the necessary and sufficient complement of Scenario Objects to stimulate and respond to the EW-Associate CM Subsystem and its USN Fighter/Attack (F/A) aircraft platform. The EW-Associate CM subsystem is expected to provide to the USN F/A aircraft: (1) Ingress and Egress Threat Avoidance Navigation and (2) Counter-Threat CM Tactical Strategy Advice within the context of an Deep Interdiction Airfield Strike Mission. As a result of this expected capability, the Scenario Objects were enumerated and placed to provide: (1) a realistic targeting objective for the strike mission as a forcing function for the USN F/A AIRCRAFT, (2) a realistic threat density, (3)

realistic threat fire control and threat and friendly C4I timing, and (4) a realistic sortie duration for both Red and Blue forces. Figure 2-1 illustrates the resulting scenario (abstracted to the class level for security and brevity reasons).

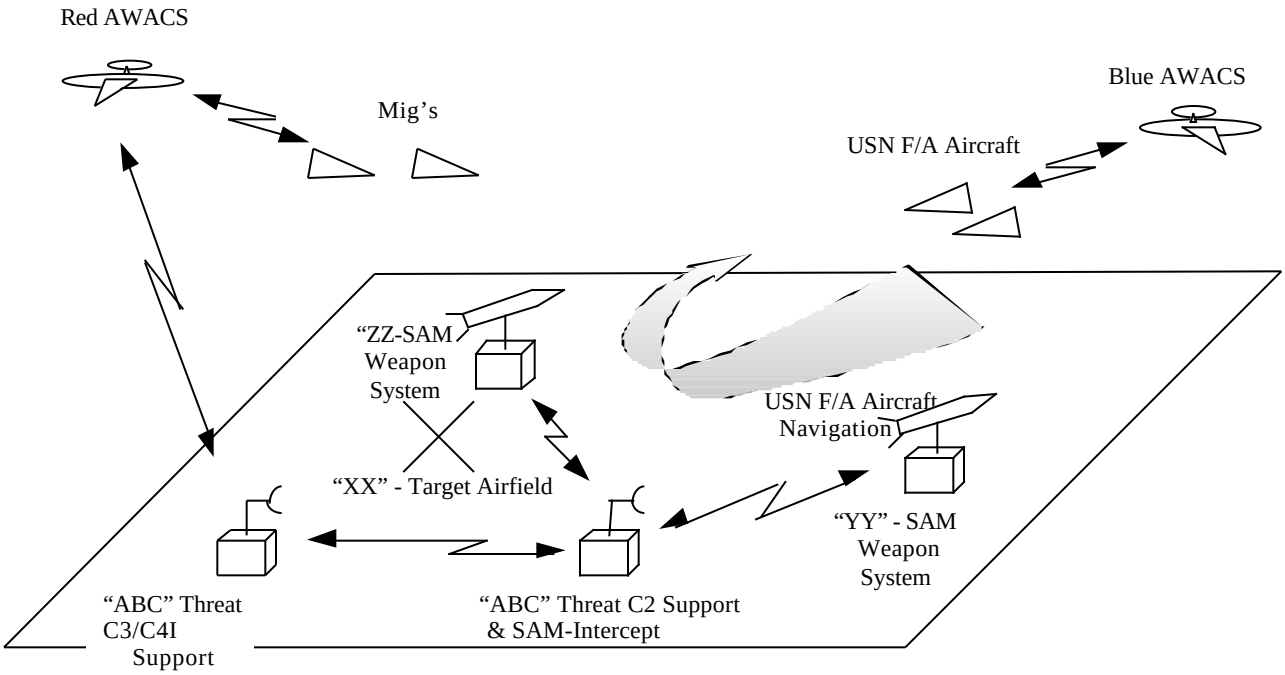

Figure 2-1 - EW-Associate ECM Subsystem D,T&E Scenario Laydown (Notional)

2.2.2 Scenario Object Interaction Allocation

This activity allocates the necessary and sufficient Scenario Object Interactions (not FOM Interactions) that must be included in the Federation Execution. For this use case, an interaction graph was developed as a visual aid in establishing the interactions. Figure 2-2 illustrates a sample of such an interaction graph for the Engineering Protofederation at the Scenario Object Class level. As successive iterations of the Scenario Development and the Conceptual Analysis are completed, the Interaction Graph must be developed for all critical Scenario Object subclasses. The table within Figure 2-2 illustrates the development of a sample set of Operational Scenario Interaction Structures. The term IPL (Interaction Parameter List) used within the Interaction Structures has been developed by the Engineering Federation to support the standardization of their interaction classes and the parameters required to support Federate Execution interactions . The Interaction Structures shown in Figure 2-2 are notional examples at the Scenario Object class level. Section

2.5 develops samples of the Interaction Structures that were developed as part of the Engineering Protofederation's FOM for the EW-Associate CM Subsystem D,T&E use case example.

2.2.3 Scenario Object Association Allocation

This activity shows a sample of an allocation of the Scenario Object Associations (not FOM Associations) that are developed in the Conceptual Analysis process for the Scenario Objects in Figure 2-2. Table 2-2 illustrates the Scenario Object Associations that were established for the EW-Associate D,T&E use case. Because most of the Scenario Object Interactions have a "two-way" association, there are twice as many entries in Table 2-2 as there were in the tabular portion of Figure 2-2. Table 2-2 shows a Context-to-USN F/A Aircraft followed by a USN F/A Aircraft-to-Context view of the Associations that correspond to the Interaction Graph that was shown in Figure 2-2.

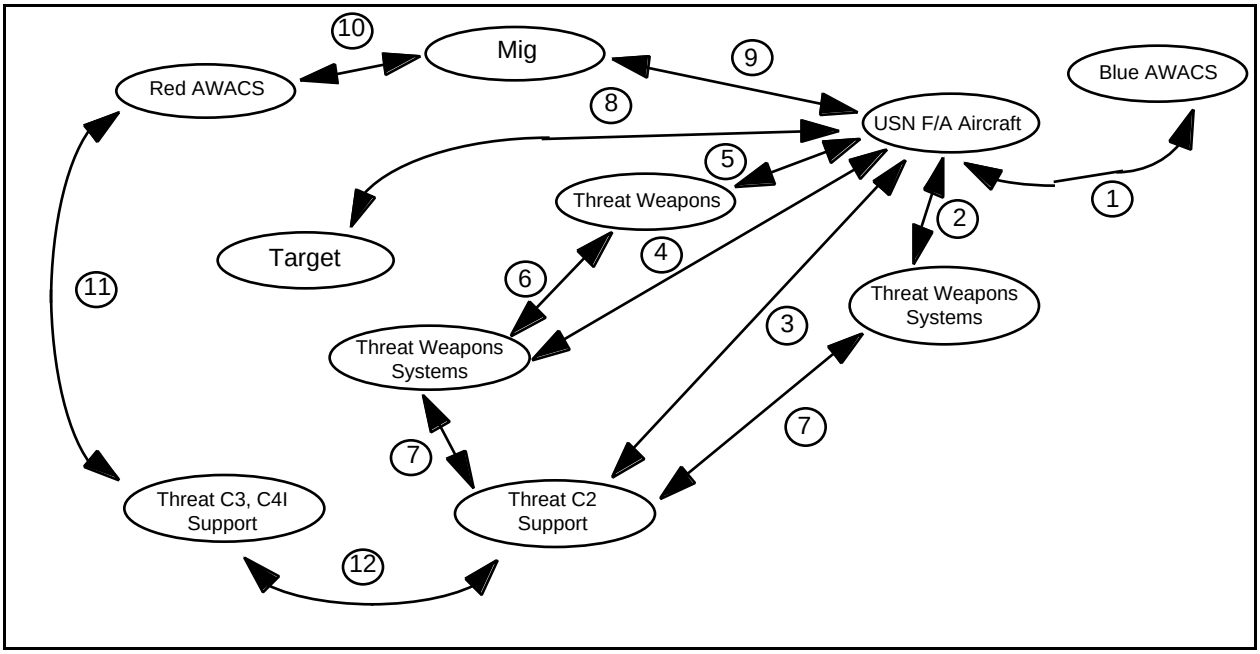

Figure 2-2 - Scenario Object Interactions Classes for the EW-Associate D,T&E Use Case

Interaction Structure Class	Initiating Scenario Object	Receiving Scenario Object	Interaction Parameter List Types
#1. Coordinate Mission Attack Data	BLUE AWACS Support Aircraft	USN F/A Aircraft	BLUE AWACS Communication IPL
#2. Conduct Enroute C2 Search/Track	Enroute Threat Platforms	USN F/A Aircraft RWR	Threat C2 Emissions IPL
#3. Conduct Enroute RF Surveillance	Enroute Threat C2/C3 Support	USN F/A Aircraft RWR	Threat C3 Emissions IPL
#4. Conduct Pre-launch Weapons C2	At-Target Threat Platforms	USN F/A Aircraft RWR	Threat SAM Emissions IPL
#5. Conduct Weapon Engagement	At-Target Threat Weapons	USN F/A Aircraft	Weapon Outcome IPL
#6. Direct Weapon Guidance	At-Target Threat Platforms	At-Target Threat Weapons	Threat C2 Emissions IPL
#7. Allocate Targetting Policy	Threat C2/C3 Support	Threat Platforms	Threat C2/C3 Comm IPL
#8. Execute Ground Target Attack	USN F/A Aircraft	Airfield Target	Weapon Outcome IPL
#9. Execute Airborne Target Intercept	MIG	USN F/A Aircraft	Threat AI Emissions IPL
#10. Communicate Intercept Data	RED AWACS	MIG	RED AWACS Comm. IPL
#11. Coordinate Threat EW Data	RED AWACS	Threat C3/C4I Support	RED AWACS Emissions IPL
#12. Assign Tracks	Threat C3/C4I Support	Threat C2/C3 Support	Threat C3/C4I Comm. IPL

Figure 2-2 - Scenario Object Interactions Classes for the EW-Associate D,T&E Use Case (continued)

Table 2-2- Scenario Object Associations for the EW-Associate D,T&E Use Case

Directing Scenario Object Class	Association Class	Receiving Scenario Object Class
BLUE AWACS Support Aircraft	Reports Tracks To	USN F/A Aircraft
Enroute Threat Systems	Directs RF Emissions To	USN F/A Aircraft
Enroute Threat C2/C3 Support Systems	Directs RF Emissions To	USN F/A Aircraft
At-Target Threat Systems	Direct RF Emissions To	USN F/A Aircraft
At-Target Threat Weapons	Intercept	USN F/A Aircraft
At-Target Threat Systems	Sends Guidance Commands To	At-Target Threat Weapons
Threat C2/C3 Support Systems	Sends Track positions and Assignments To	Enroute and At-Target Threat Systems
Target	Radiates Signature To	USN F/A Aircraft
MIG	Navigates To	USN F/A Aircraft
RED AWACS	Sends Navigation Commands To	MIG
RED AWACS	Sends USN F/A Aircraft Track State To	Threat C3/C4I Support Systems
Threat C3/C4I Systems	Sends Target Assignments To	Threat C2/C3 Support Systems
USN F/A Aircraft	Sends Track Requests To	BLUE AWACS Support Aircraft
USN F/A Aircraft	Detects, Tracks, Assesses, and Avoids	Enroute Threat Systems
USN F/A Aircraft	Detects, Tracks, Assesses, and Avoids	Enroute Threat C2/C3 Support Systems
USN F/A Aircraft	Detects, Tracks, Assesses, and Deceives	At-Target Threat Systems
USN F/A Aircraft	Detects, Tracks, Assesses, and Deceives/Decoys	At-Target Threat Weapons
At-Target Threat Weapons	Send Signatures and State To	At-Target Threat Systems
Enroute and At-Target Threat Systems	Send Current Track Status To	Threat C2/C3 Support Systems
USN F/A Aircraft	Navigates To and Launches Weapon At	Target
USN F/A Aircraft	Detects, Tracks, Assesses, and Avoids	MIG
MIG	Sends Track Request To	RED AWACS
Threat C3/C4I Support Systems	Sends Track Request To	RED AWACS
Threat C2/C3 Support Systems	Sends Targeting Status To	Threat C3/C4 Support Systems

2.2.4 Scenario Object Behavior State Allocation

This activity iteratively allocates Scenario Object Behavior specified during Conceptual Analysis to each type of Scenario Object. Currently, there is no OM Template to support the specification of Scenario Object Behavior. It is the opinion of the Engineering Protofederation, that Scenario Object Behavior must be communicated in a manner that is similar to the other OM specification templates. At the time of the OMT V0.2 document, the Engineering Protofederation was still

developing the spectrum of Scenario Object Behavior States, therefore, this section could not be further elaborated. The expected output of this process is most likely some type of "finite state" machine specification that will characterize the states, state transitions, and transition attribute thresholds necessary to give the Scenario both directionality and dynamics. The states and state transition diagrams must be defined as a function of the Object types and their respective associations and interaction attributes.

2.3 Conceptual Analysis

The purpose of the Conceptual Analysis process is to provide the SUE Operational Context specification as the basis for Federation Design requirements development. Conceptual Analysis is composed of three main activities:

- Static Scenario Object and Object Interaction Model Development
- Scenario Object Associations Model Development, and
- Scenario Object Dynamic Behavior Model Development.

2.3.1 Static Scenario Object and Object Interaction Model Development

This activity successively decomposes the Scenario Object classes into subclasses and associated subclass object interactions to the degree required for Federation Execution. In this use case, the Engineering Protofederation developed a baseline Scenario and a corresponding set of interactions by decomposing the Execution Sponsor's Problem Domain and Operational Context into classes of Scenario Objects. Figure 2-3 illustrates the baseline static SUE Object and Operational Context Object Models. Using Figure 2-3 a notional "NxM" Object Interaction matrix was developed that characterized the top-level SUE-to-Operational Context Interactions that would be of interest to the Execution Sponsor. Table 2-3 illustrates notional "NxM" Object Interactions that were developed. The table shows both Operational Context-Object-Initiated and SUE-Object-Initiated interaction structures. The Operational Context-Object-Initiated interactions are listed first in each table cell followed by the SUE-Object-Initiated interactions. The baseline Scenario Objects (SUE Objects and Operational Context Objects) and Interactions in Table 2-3 were used as interaction classes in the Scenario Development process to develop the baseline Interaction Graph and interaction types that were shown in Figure 2-2.

Figure 2-4 illustrates a further decomposition of the baseline SUE Object Model. This is a sample of the result of successive iterations on the baseline SUE Object Model to achieve the granularity required for the Sponsor's Federation Execution. Decomposing the SUE Object Model to the level shown requires a corresponding decomposition to the Operational Context Objects so that their interactions will be at the same level. Though not developed in detail for this document, a sample of how the Operation Context Objects would need to be decomposed to correspond to the decomposition in Figure 2-4 is shown in Figure 2-5.

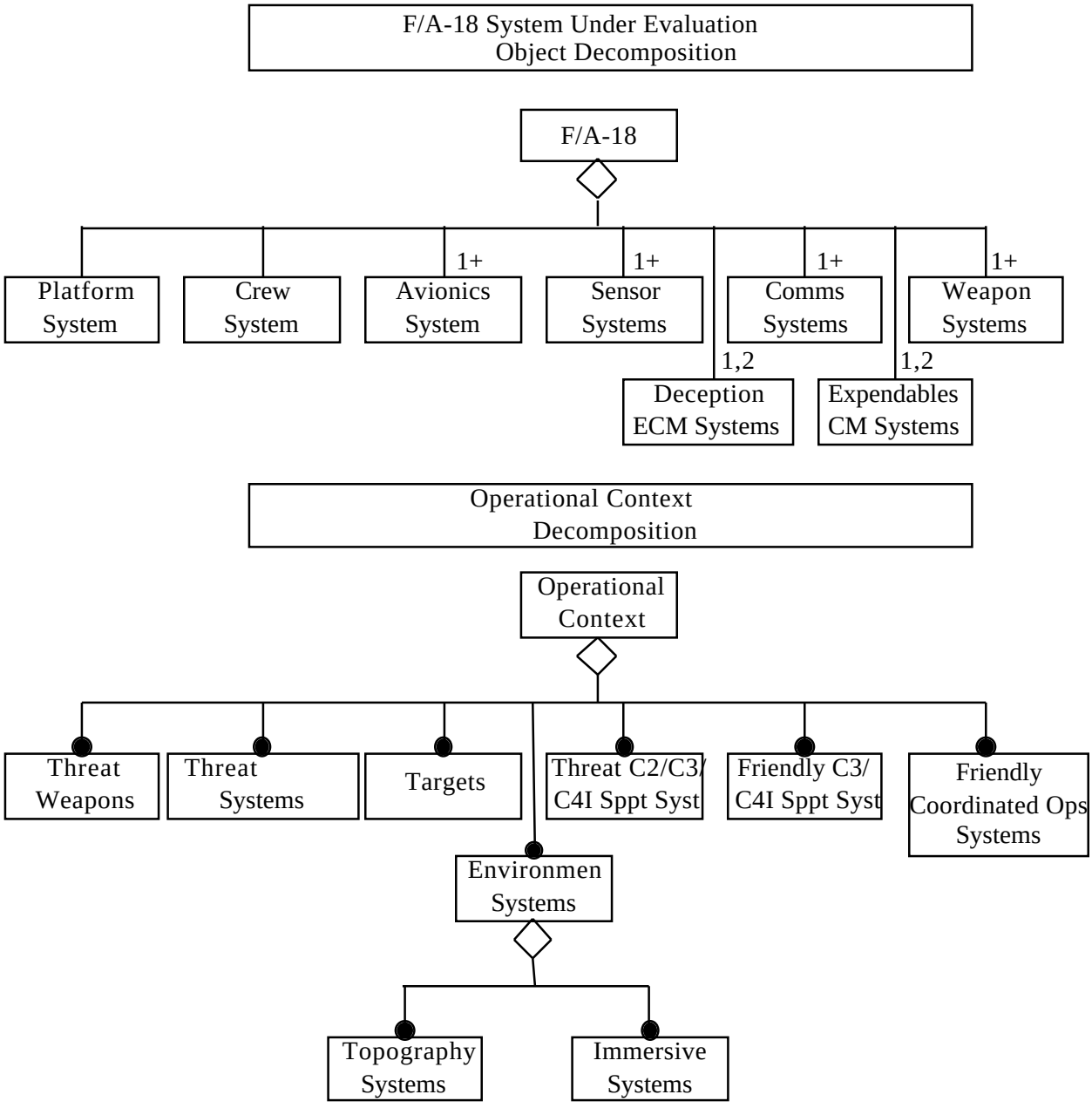

Figure 2-3 - Baseline Scenario Object Decomposition

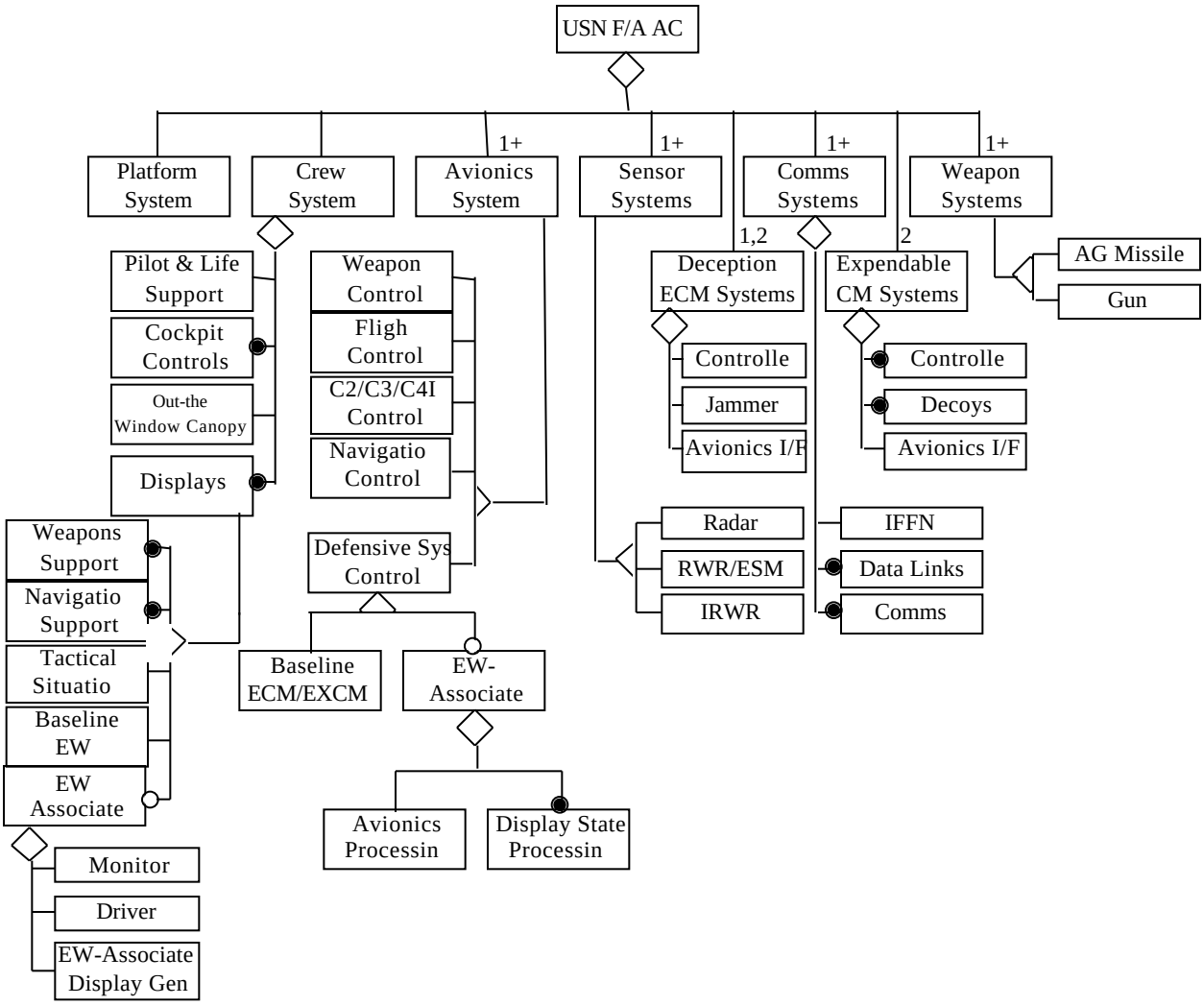

Figure 2-4 - Necessary and Sufficient USN F/A AIRCRAFT (SUE) Object Decomposition for Representing the EW-Associate CM Subsystem in an Interactive Operational Context

Table 2-3 - Base Class SUE and Operational Context Objets and Interactions for EW-Associate D,T&E Engineering Proto-Federation Execution

Operational Context Objects	System Under Evaluation Objects and Associated Interactions with the Operational Context Objects [Operational Context Object Initiated /SUE Object Initiated]							
	Platform Systems	**Crew Systems**	**Avionics Systems**	**Sensor Systems**	**DECM Systems**	**EXCM Systems**	**Weapon Systems**	**C2/C3I/C4I Systems**
Threat Weapons	Directs Damage/ Assesses Damage	Sends Signals/ Commands Evasion	None/ Assesses & Directs Evasions	Sends Signals/ Processing	Sends Signals/ Deceives	None/ Decoys	None/None	None/None
Threat Weapon Systems	Sends Signals/ Sends Signals	Sends Signals/ Commands Avoidance	None/ Assesses & Directs Avoidance	Sends Signals/ Processing	Sends Signals/ Deceives	None/ Decoys	Observes/ Sends Signals	IFFN / IFFN
Targets	None/None	Send Signals/ Commands Attack	None/ Assesses & Directs Attack	Sends Signals/ Processing	None/None	None/None	Send Signals/ Directs Damage	Sends Signals/ Sends Signals
Threat C2, C3 & C4I Support Systems	Sends Signals/ Sends Signals	None/None	None/ Assesses & Directs Avoidance	Sends Signals/ Sends Signals	Sends Signals/ Deceives	None/ Decoys	Observes/ Directs Damage	IFFN/IFFN
Friendly C3 & C4 Systems	None/ Sends Signals	Sends Signals/ Communicates	None/ Assesses & Directs C3/C4	Sends Signals/ Sends Signals	None/None	None/None	None/None	Send Comms/ Send Comms
Geographic Environment	Resists Impact/ Collision	Sends Signals/ Commands Avoidance Navigation	None/ Assesses & Directs Navigation	Sends Signals/ Sends Signals	None/None	None/None	Resists Impact/ Detonates With	None/None
Immersive Environment	Resists/Fly Through	Sends Signals/Sees Through	None/ Assesses & Directs Navigation	Sends Signals/ Sees Through	None/Sees Through	Resists/Fly Through & Disperse within	Resists/ Fly Through	Sends Signals/ Sends Signals

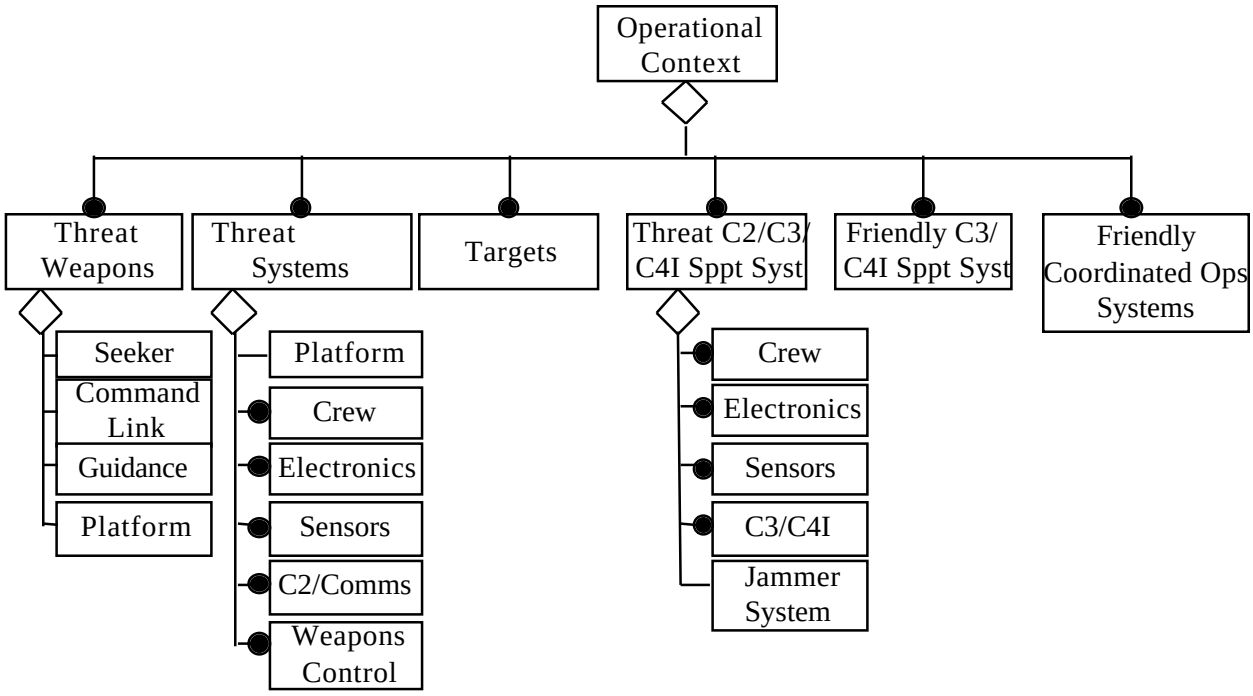

Figure 2-5 - Sample Operational Object Decomposition To Correspond to Lowest-Level EW-Associate CM Subsystem Decomposition

2.3.2 Scenario Object Association Model Development

This activity develops the Associations between the Scenario Objects that have been decomposed during the Static Scenario Object development process. The purpose for the Associations is to define the components and directionality associated with the Interacting Scenario Objects. For this use case, the Engineering Protofederation used the notion of the Directed Graph as a starting point for establishing the Scenario Object Associations. The Directed Graph is developed during the Conceptual Analysis as a way of identifying the necessary and sufficient Scenario Object Associations that are required to provide the Scenario "functional directionality". Figure 2-6 illustrates a directed graph for the associations between the USN F/A Aircraft and its Operational Context Objects. Table 2-2 illustrated an example of how the Allocation Classes shown in Figure 2-6 are expanded into Association Allocations for the Enumerated Scenario Objects.

2.3.3 Scenario Object Behavior Model Development

The Scenario Behavior Model Development process develops a specification for the dynamic behavior of the Scenario. This process iterates with and uses the semantics and processing of the

CMMS in order to define the necessary and sufficient behaviors that satisfy both the Operational Scenario experts (e.g. Warfighting/SUE users) and Federation Sponsors. The Engineering Protofederation has not completed the Scenario Object Behavior State Characterization as of this time.

Directing Scenario Object Class	Association Class	Receiving Scenario Object Class
Friendly C3/C4 Support System	Reports Tracks To	USN F/A Aircraft
Threat Weapon System	Directs Emission To	USN F/A Aircraft
Threat C2/C3 Support System	Directs Emission To	USN F/A Aircraft
Threar Weapon	Guides To	USN F/A Aircraft
Threat Weapon System	Sends Guidance Commands	Threat Weapons
Threat C2/C3 Support System	Sends Track Positions Assignments To	Threat Weapons Systems
Target	Radiates Signature	USN F/A Aircraft
USN F/A Aircraft	Sends Requests To	Friendly C3/C4I Support Systems
USN F/A Aircraft	Detects, Tracks, Assesses, Avoids, and Deceives	Threat Weapon Systems
USN F/A Aircraft	Detects, Tracks, Assesses, Avoids, and Deceives	At-Target Threat Weapons
USN F/A Aircraft	Navigates To and Weapon At	Target

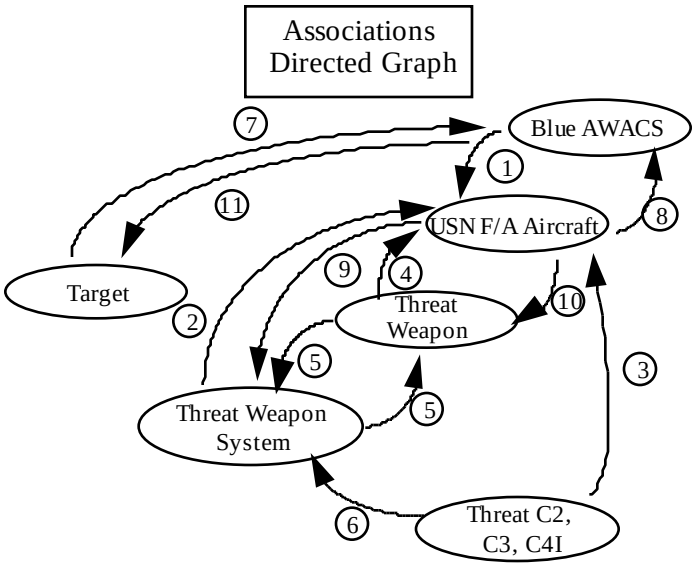

Figure 2-6 - Baseline SUE and Operational Context Object Associations for the EW-Associate CM Subsystem D,T&E Use Case

The output of the iterative process of Conceptual Analysis and Scenario Development is the set of Objects, Interactions, Associations, and Behaviors that are necessary and sufficient to define the Operational World view of the Execution Sponsor in the terms of the Federation Designer/Developer. As the Federation Development and Execution process model matures within any given domain, these outputs will be formatted into Federation Object Model specifications for the Federation Designer and FOM Developer.

2.4 Federation Design

The Federation Design process transforms the Execution Sponsor's Federation Execution specifications (from the Operational World view) into a Federation Development and Execution specification. Federation Designers and Federation Developers will work within the Federation World view to develop the Federation Execution. Though the Federation Development and Execution Process model describes a robust process for Federation Design, the Federation Design process was artificially constrained during the HLA prototyping phase in a number of ways. First, since the HLA Protocol Catalog did not exist, the required protocols for this application were implicitly defined during Scenario Development. Next, there did not exist an electronic library of FOMs/SOMs from which the user could select to begin the design of the Federation Execution. Finally, since the participants in the federation were pre-chosen, there was no need to analyze and determine suitability of existing SOMs. Therefore, most of the effort in this phase of federation development focused on development of the federation requirements.

The activity that was performed by the Engineering Protofederation for the use case was driven by the Reference Federation Management Requirements from the Federation Execution Sponsor's Objectives process. Most of the simulations were legacy, the physical communication architecture was a given (DSI/T1 lines), and the requirements for ownership were somewhat constrained by specifically required hardware-in-the-loop facilities. As a result of these significant constraints, the Federation Design process concentrated on how to work within these constraints to implement a notional EW-Associate CM Subsystem D,T&E Protofederation Execution.

As a result of a set of design meetings, the Engineering Protofederation was able to develop a Processing Architecture which could be used to define the requirements for a test system for designing and testing feasible Federation Executions. Figure 2-7 illustrates the Processing Architecture that was developed for the use case. Figure 2-7 shows the allocation of ownership of the Scenario Objects that were developed during the Conceptual Analysis. The allocation of the

Scenario Objects to the various "Nodes" of the Architecture was one-to-one with the allocation of many of the existing SOMs to the Federation Execution. Since many of the simulations were legacy, the primary Engineering Protofederation design issues addressed revolved around the management of surrogate simulations and the activation and deactivation of select simulations whose functionality is a periodically required as a function of the events of the scenario.

2.5 Federation Development

This process must develop the required FOM, the Execution Management Object Model, the RTI functionality, and Communication Systems services that will be needed to support the Federation Execution. Since the Engineering Protofederation's Execution Design was constrained by the processing components displayed in Figure 2-7, the primary Engineering Protofederation FOM development activity was centered around developing Surrogate Simulation Objects and interfacing existing SOMs into the FOM development process and the HLA framework. Figure 2-7 identifies six physical locations where Engineering Protofederation simulations will be executing during the Federation Execution stage. The figure shows: (1) that the Federation Execution must use DSI/T1, (2) that each Federation Member will be developing HLA conforming Middleware and Surrogates to help ensure both HLA compliance and legacy simulation interoperability, and (3) that there are specific (e.g., non-transferable ownership) requirements for portions of the Federation Object Model due to the notional Federation Execution Reference Requirements for Execution Management.

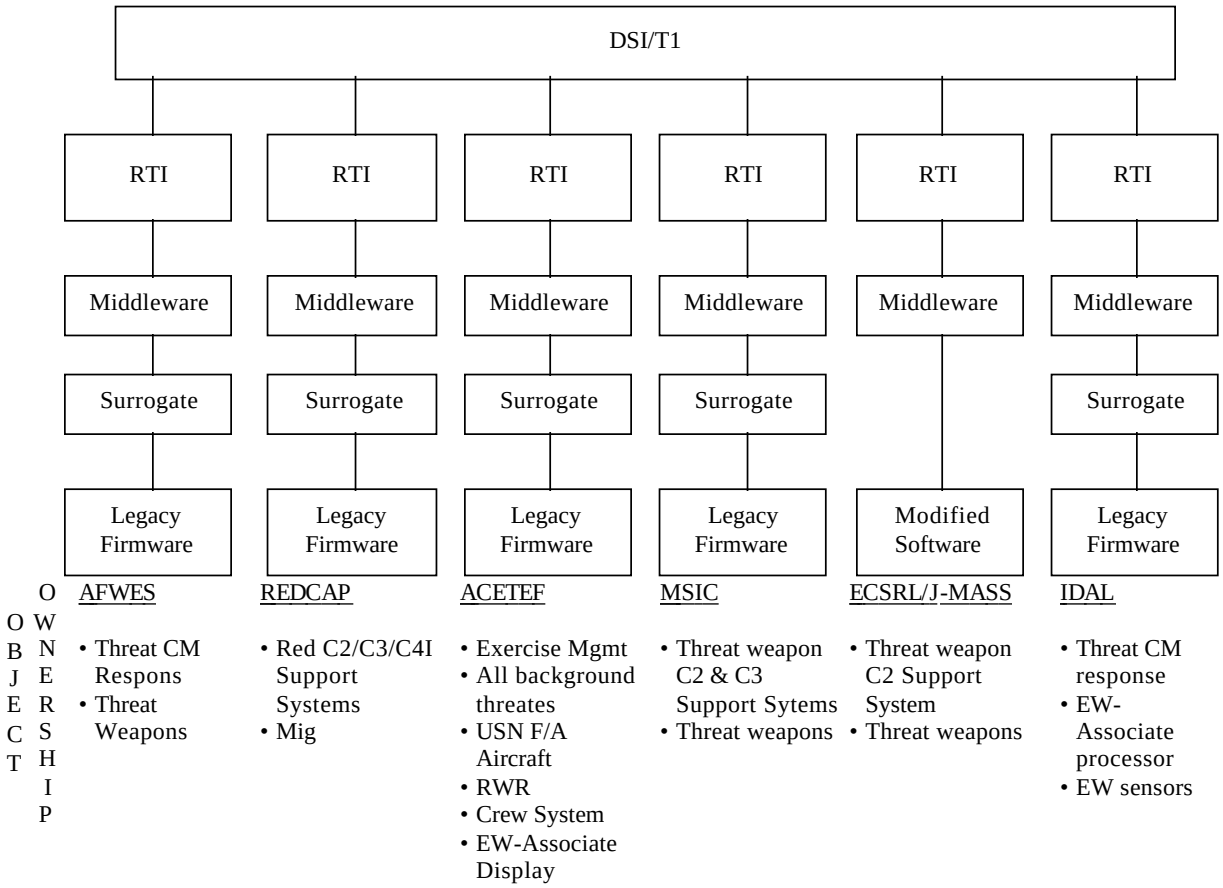

Figure 2-7 - Processing Architecture for the EW-Associate CM Subsystem D,T&E Use Case

2.5.1 FOM Development

The FOM Development activity is one of the activities associated with the Federation Development and Execution process. For the use case, the Engineering Protofederation is currently finalizing their FOM Development Specification. This development specification contains the necessary and sufficient Federation Object Model Decomposition, Interactions, Associations, and Attribute and Exchange specifications that are required to meet the objectives of the application. HLA OMT formats were utilized directly during development of the FOM, so no intermediate translation step to OMT formats was required.

2.5.1.1 EW-Associate CM Subsystem D,T&E Use Case Federation Object Model Decomposition

Figure 2-4 depicted the notional USN F/A Aircraft Object Model Decomposition that was necessary for the representation of the SUE in the Operational Context required by the notional Sponsor. Combining the necessary SUE Object Model Decomposition with the Federation Development and Execution requirements associated with: (1) integrating the EW-Associate CM Subsystem into the USN F/A Aircraft simulator at ACETEF and (2) using the high-fidelity Threat-to-CM stimulation/response laboratories at AFEWES, ECSRL, and MSIC, yields the derived notional Engineering Protofederation Federation Object Model. The static model SUE objects of this derived notional Federation Object Model are illustrated in Figure 2-8. The Engineering Protofederation also derived the necessary and sufficient Scenario Object Decompositions that would support the required SUE-to-Context Object interactions. For this use case, the sample elements of the derived FOM static Object Model Class Structure Template are shown in Table 2-4. A sample of the corresponding use case Component Structure Template is shown in Table 2-5. The intent of these derived FOM illustrations is to provide a "glimpse" into the relationship between the systems engineering processes that support Federation Development and Execution and the evolution of the FOM. The objects in the Class Structure and the Component Structure Templates in Tables 2-4 and 2-5 are only representative of the extensive FOM development activities on-going within the Engineering Protofederation.

2.5.1.2 EW-Associate CM Subsystem D,T&E Use Case Federation Object Model Interactions

Table 2-3 depicted the necessary and sufficient USN F/A AIRCRAFT Object and Operational Context Model Interaction Classes to represent the notional capability of the Execution Sponsor's SUE Object-to-Operational Context Object Interaction Requirements. Based on the constraints associated with the Reference Federation Execution Management Requirements, the Engineering Protofederation developed the EW-Associate CM D,T&E use case Object Interaction Structures illustrated (in a representative sample) in Figure 2-9. The Engineering Protofederation assessed the necessary and sufficient Scenario Object Interactions to support the required SUE decomposition. The direct and indirect interactions that are required between the USN F/A Aircraft's subsystems, the EW-Associate CM Subsystem, and the Operational Context Objects yielded the required Use Case FOM (sample) Interactions Template shown in Table 2-6.

2.5.1.3 EW-Associate CM Subsystem D,T&E Use Case Federation Object Model Associations

Figure 2-6 depicted the necessary and sufficient USN F/A Aircraft Object and Operational Context Model Interactions to represent the notional capability of the Execution Sponsor's SUE Object-to-Operational Context Object Interaction Requirements. The Engineering Protofederation assessed the necessary and sufficient Scenario Object Interactions to support the required SUE decomposition. The direct and indirect interactions that are required between the USN F/A Aircraft's subsystems, the EW-Associate CM Subsystem, and the Operational Context Objects yielded the required Use Case (sample) FOM Associations shown in Table 2-7. Table 2-7 illustrates two of many segments of Object Associations that are present in the notional EW-Associate CM D,T&E Federation Execution: (1) a EW-Associate CM Subsystem view and (2) a USN F/A Aircraft Systems view. As can be seen by combining the Interaction Graphs of Figures 2-2 and 2-9, these two views are fundamentally connected via Association Subclass relationships. Table 2-7 shows an association sequence that starts at the highest levels of object interaction and finishes at the lowest level of object interaction. Table 2-7 presents one thread of numerous that would be required to fully define the interoperation of the Federates.

2.5.1.4 EW-Associate CM Subsystem D,T&E Use Case Federation Object Model Attributes

Based on the derived FOM requirements illustrated in Table 2-6, the Engineering Protofederation developed the necessary and sufficient USN F/A Aircraft Object-to-Operational Context Object Model attribute exchanges to represent the notional capability of the Execution Sponsor's SUE Object-to-Operational Context Object Interaction Requirements. The Engineering Protofederation assessed the necessary and sufficient Scenario Object attribute exchanges to support the required SUE-to-Operational Context interaction sensitivity. The direct and indirect interactions that are required between the USN F/A Aircraft's subsystems, the EW-Associate CM Subsystem, and the Operational Context Objects yielded the required Use Case FOM (sample) Attribute exchange shown in Table 2-8. The Engineering Federation is developing a specific set of protocols (called Interaction Parameter Lists (IPLs)) that will be used to "package" FOM attributes in accordance with the needs of the Federates. The IPLs will consolidate sets of FOM attributes, formerly listed individually in the FOM Attributes Template, into publishable packages. The packaging of the FOM attributes will be domain specific. For the OMT (V0.2) document, the use case (e.g., Table 2-8) reflects a sample of the Engineering Protofederation's FOM Attribute Template related to the notional EW-Associate D,T&E use case.

2.6 Summary

This concludes the Engineering Protofederation use case for the OMT V0.2 OMT document. Extensions and modifications to this use case will be forth-coming in subsequent releases of the OMT document. The remainder of this current document provides the specific OM Templates associated with the previous paragraph references.

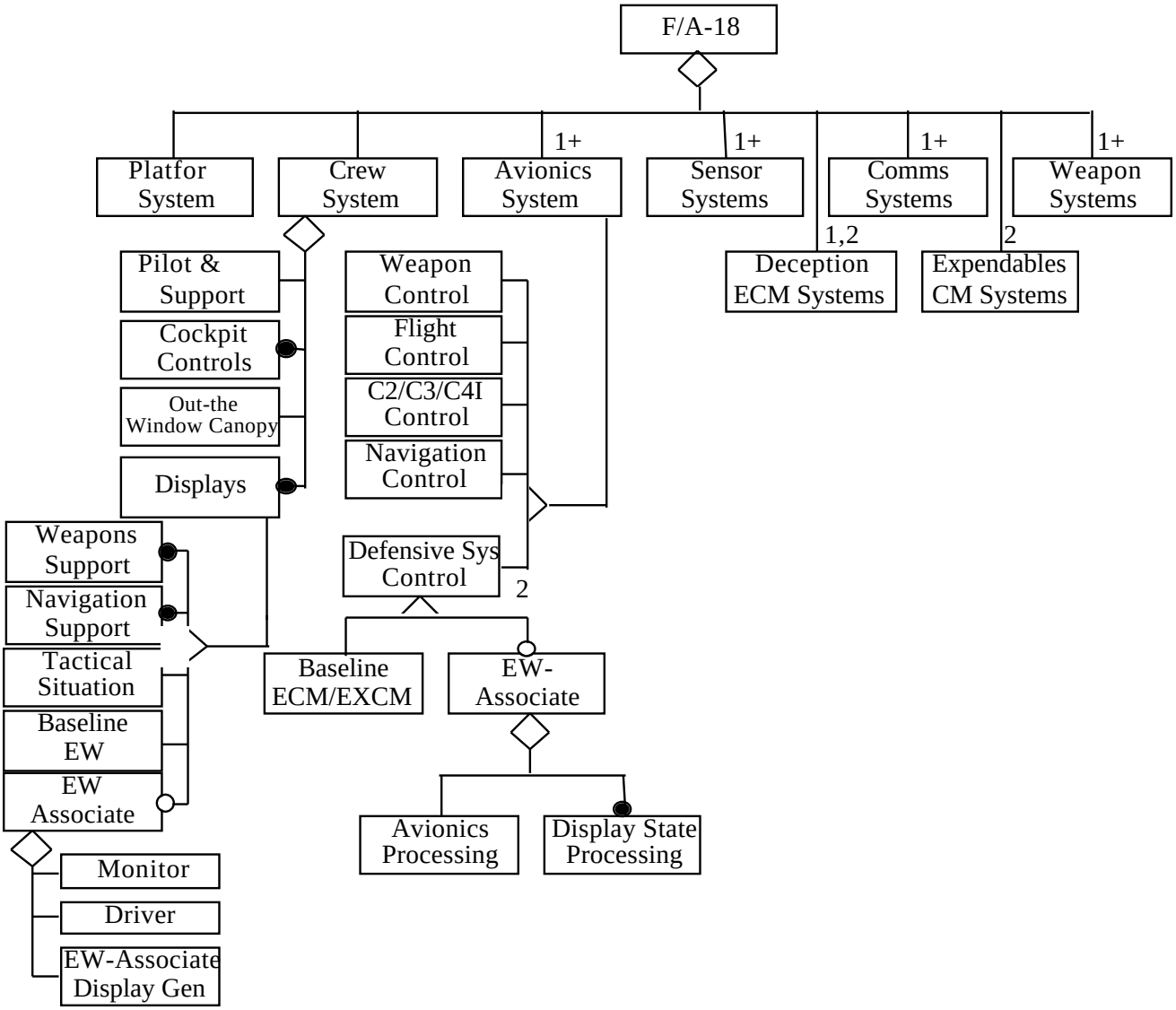

Figure 2-8- SUE FOM (Sample) Decomposition for the EW-Associate CM D,T&E Use Case

Table 2-4- EW-Associate CM D,T&E Use Case FOM (Sample) Class Structure

Class Structure			
Air Vehicle	Fixed Wing	Fighter Attack	USN F/A AIRCRAFT, MIG
		C2/C3/C4 Support Aircraft	E/A-6B, BLUE AWACS, RED AWACS
Land Site	Airfield	JCS-Approved Scenario Object Laydown	"XX"-Airfield
Threat C2/C3/C4I Support Systems	C3/C4I Support Systems	Sector Ops Center	"ABC" Sector Center
		Intercept Ops Center	"ABC"Intercept Ops Center
		SAM Intercept Center	"YY, ZZ SAM" Intercept Center
	C2 Support Systems	SAM Battery C2 System	"YY"-SAM C2, "ZZ"-SAM C2
Avionics System	Weapon Control	Attack Aircraft Flight Control	USN F/A AIRCRAFT Fire control
	Flight Control	Attack Aircraft Flight Control	USN F/A AIRCRAFT Flight control
	Defensive System Control	Adv. CM Subsystem	EW-Associate CM Subsystem
	Navigation Control	Attack Aircraft Navigation Control	USN F/A AIRCRAFT Navigation System
	C3/C4I Control	Attack Aircraft C3/C4I Control	USN F/A AIRCRAFT C2/C3/C4I System
	Data/Comms. Control	Attack Aircraft Data Link & Comms. Control	USN F/A AIRCRAFT Data Link & Comms Control
ECM	Radar Deception	USN Pod Mounted	ECM System Type "XYZ"
Expendables	RF Jammers		
	RF Decoys	Towed RF	Type "XYZ"
		Chaff	Type "XYZ"
	IR Decoys	Multi-Spectral	Type "XYZ"
		Flares	Type "XYZ"
Weapon	Missile	SAM	SAM-"YY", SAM-"ZZ"
		AAM	AAM-"XYZ"
Crew System	Aircraft Pilot System	Attack Aircraft Pilot System	USN F/A AIRCRAFT Pilot System
	Ground Site Operator	Threat C2 Operator System	SAM-"YY" C2 Operator System

Table 2-5 - EW-Associate CM D,T&E Use Case SUE FOM (Sample) Component Structure

Component Structure		
USN F/A AIRCRAFT Air Vehicle	Platform System 1	
	Crew System 1	Pilot & Life Support 1
		Cockpit Controls 1+
		Out-the-Window Canopy 1
		Displays 1+
	Avionics Systems 1+	Weapon Control 1
		Flight Control 1
		C2/C3/C4I Control 1
		Navigation Control 1
		Defensive Systems Control 2
	Deception ECM System 1,2	Near-Term ECM System
		Far-Term ECM System
Crew System	Pilot & Life Support 1	
	Cockpit Controls 1+	
	Out-the-Window Canopy 1	
	Displays	Baseline USN F/A AIRCRAFT 1+
		EW-Associate 1
Avionics Systems	Weapon Control 1	
	Flight Control 1	
	C2/C3/C4I Control 1	
	Navigation Control 1	
	Defensive Systems Control 2	Baseline ECM/EXCM Control 1
		EW-Associate Control 1
Deception ECM System	Near-Term ECM System 1	Baseline USN F/A AIRCRAFT System
	Far-Term ECM System 1	EW-Associated Augmented System
Defensive Systems Control	EW-Associate Control 1	Avionics Processing 1
		Display State Processing 1

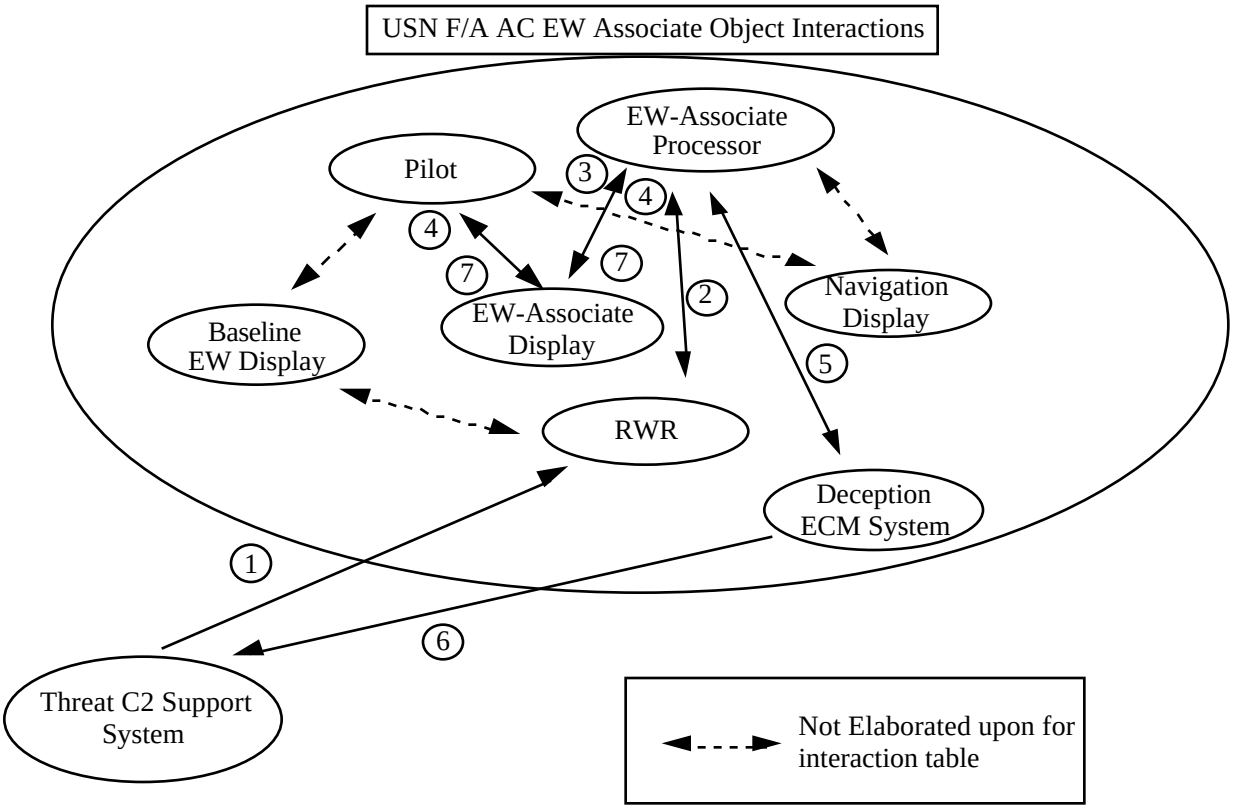

Figure 2-9 - SUE-to-Operational Context Object Interaction Requirements (Sample) for the EW-Associate CM D,T&E Use Case

Table 2-6- EW-Associate CM D,T&E Use Case FOM (Sample) Interactions

Inter-action No.	Interaction Structure	Initiating Object	Affected Attributes	Receiving Object/Area	Affected Attributes	Interaction Parameters
1	Send Threat Signals	RF Threat SAM C2 Radar System	Signal Power, Signal Freq.	USN F/A AIRCRAFT RWR	Perceived Threat State Declarations	Range, Viewing/Transmitting Angle offset, Transmit-to-Receive Frequency Alignment
2	Update Threat State Declaration	RWR	Measured Threat State Attributes	EW-Associate Processor	Fused Perceived Threat State Attributes and Threat ID	Threat Attribute Correlation Parameters
3	Update Threat Assessment and ECM Response State	EW-Associate Processor	Display State Messages and Attributes	EW-Associate Display	Display Symbology	EW-Associate Display Processor State Messages and Attributes
4	Select Jamming Program	Pilot/ EW-Associate Display	ECM Control Settings	EW-Associate Processor	ECM Select States	EW-Associate Processor/Controller States and Messages
5	Activate Jamming Subsystem	EW-Associate Processor	ECM Mode Command Messages	Deception ECM Subsystem	ECM Mode Settings	EW-Associate Jam Program Select Message
6	Send Jamming Signals	Deception ECM Subsystem Emitter	Signal Power, Signal Frequency	Threat C2 Radar Receiver	Perceived Friendly State Declarations	Range, Viewing/Transmitting Angle offset, Transmit-to-Receive Frequency Alignment
7	Update Jamming Effectiveness Assessment	EW-Associate Processor	Display State Messages and Attributes	EW-Associate Display	Display Symbology	EW-Associate Display Processor State Messages and Attributes

Table 2-7 - EW-Associate CM D,T&E Use Case FOM (Sample) Associations

First Class	Association	Second Class
RED AWACS	detects	USN F/A AIRCRAFT
RED AWACS	reports_ track_to	“ABC” Sector Ops Center
“ABC” Sector Ops Center	assigns_track_to	“ABC” SAM Intercept Ops Center
“ABC” SAM Intercept Ops Center	allocates_track_to	“YY” SAM C2 Support System
“YY” SAM C2 Support System	directs_ RF_ acq/tracks_signals_at	USN F/A AIRCRAFT RWR
The above associations will continue to operate throughout the time that the USN F/A AIRCRAFT is within the Mission Space **The associations below will continue to operate throughout the time that the USN F/A AIRCRAFT is being engaged by threats**		
USN F/A AIRCRAFT RWR	detects	“YY” SAM C2 Support System Signals
USN F/A AIRCRAFT Pilot	notices	RWR Display
USN F/A AIRCRAFT Pilot	activates	EW-Associate CM Subsystem
RWR	sends_”YY” SAM C2_states_to	EW-Associate Processor
EW-Associate Processor	sends_ECM jammer program options _to	EW-Associate Display
Pilot/EW-Associate Display	selects & sends_ECM jammer program_to	EW-Associate Processor
EW-Associate Processor	selects_ECM mode_for	USN F/A AIRCRAFT Deception ECM System
USN F/A AIRCRAFT Deception ECM System	directs_Jamming Signal_to	“YY” SAM C2 Radar Receiver
“YY” SAM C2 Radar Receiver	processes	USN F/A AIRCRAFT RCS-to-Jam Signals
“YY” SAM C2 Radar Receiver	is_deceived_by	USN F/A AIRCRAFT Deception ECM System
“YY” SAM C2 Radar Receiver	misdirects_RF_acq/track_signals_at	USN F/A AIRCRAFT RWR

Table 2-8- EW-Associate CM D,T&E Use Case FOM (Sample) Attributes

Object/ Interaction	Attribute/ Parameter	Data Type**	Resolu-tion	Accu-racy	Update Type	Update Rate	Condition	Transfer-able
Send Threat Signals	Signal Power	Float	TBD	TBD	Periodic	10Hz	Always	Yes
	Signal Freq.	Float	TBD	TBD	Conditional	10Hz*	Always	Yes
Update Threat State Declaration	Measured Threat State Attributes	IPL Type	N/A	N/A	Periodic	10Hz	N/A	No
Update Threat Assessment and Response State	EW-Associate Display State Attributes	IPL Type	N/A	N/A	Conditional	2Hz*	N/A	No
Select Jamming Program	ECM Control Settings	Integer	N/A	N/A	Conditional	2Hz*	N/A	No
Activate Jamming Subsystem	ECM Mode Command Message	IPL Type	N/A	N/A	Conditional	2Hz*	N/A	No
Send Jamming Signals	Signal Power	Float	TBD	TBD	Periodic	10Hz	Always	Yes
	Signal Freq.	Float	TBD	TBD	Conditional	10Hz*	Always	Yes
Update Jamming Effectiveness Assessment	EW-Associate Display State Attributes	IPL Type	N/A	N/A	Conditional	2Hz*	N/A	No

*sampling rate to detect event
**IPL (Interaction Parameter Lists) is a hybrid of Types.